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No. 912

A SUBPRESS FOR COMPRESSIVE TESTS

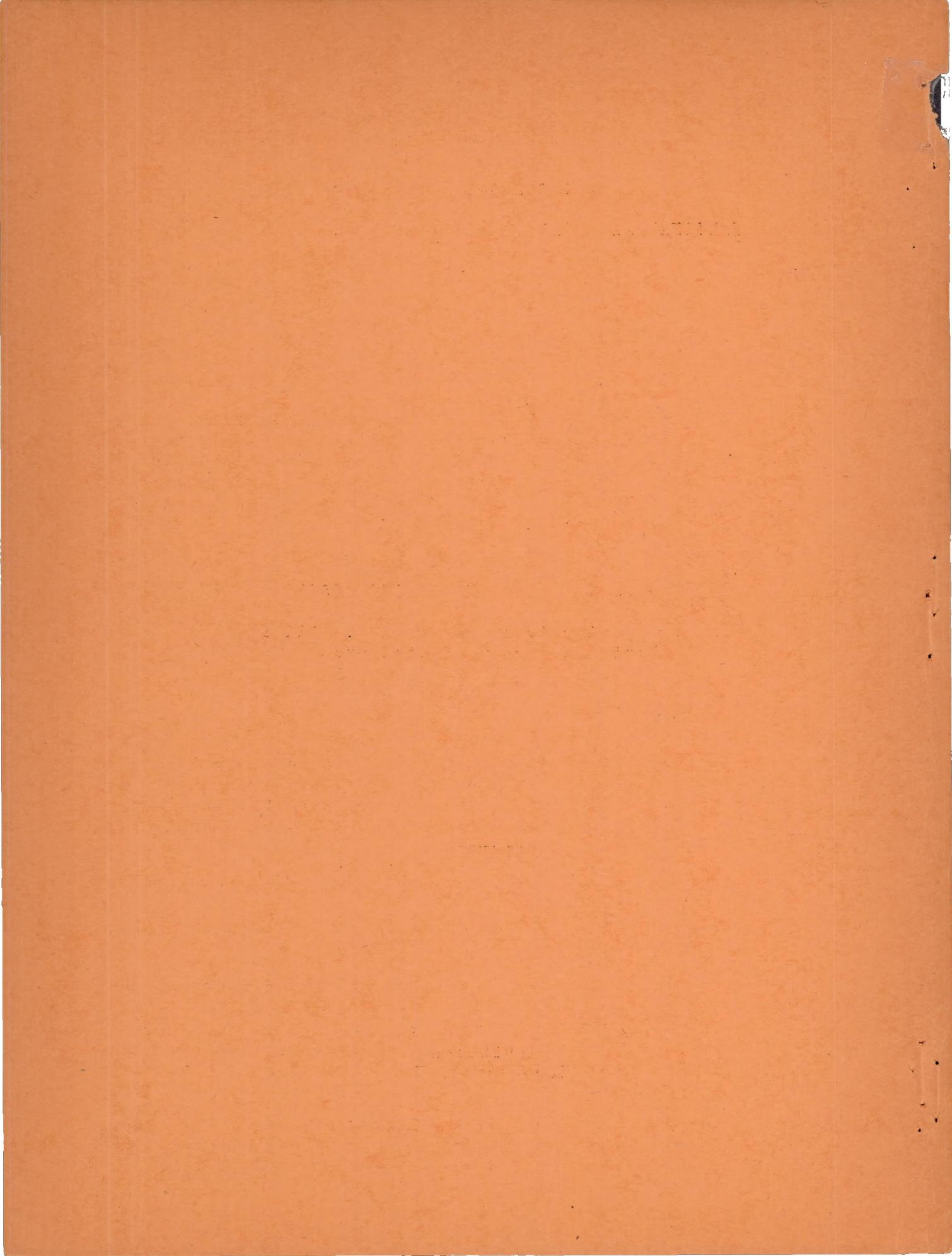
By C. S. Aitchison and James A. Miller
National Bureau of Standards

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A SUBPRESS FOR COMPRESSIVE TESTS

By C. S. Aitchison and James A. Miller

SUMMARY

A subpress for compressive tests is described. The subpress was designed primarily for use in developing and investigating methods for testing thin sheet metal in compression. Provision was made for testing fixed-end and flat-end specimens with or without various types of lateral support against buckling.

Compressive stress-strain data for a sheet of 0.032-inch 24S-RT aluminum alloy were obtained with the subpress by the pack method and by the single-thickness method. The data showed small scatter and the stress-strain curves obtained by the two methods were in close agreement.

INTRODUCTION

The subpress described in this report was constructed as part of a project on methods of testing thin sheet metal in end compression which is being conducted at the National Bureau of Standards for the Bureau of Aeronautics, Navy Department.

A subpress was desired which would serve two purposes:

1. Rigid clamping and axial loading of single strips to determine buckling loads

2. Axial loading of specimens and slender packs to obtain compressive stress-strain data

A device to serve the first purpose was desired as a result of buckling tests made some years ago by the authors to detect differences in compressive properties of sheet metal. It was found in relatively simple tests with improvised fixtures that the buckling loads of strips of suitable dimensions may be used to indicate differences in compressive yield strength. The differences

in buckling loads were of the same order as the differences in the buckling loads derived from the stress-strain curves on the basis of reduced modulus. However, the deviation from ideal clamping was too great to obtain a quantitative check against the compressive stress-strain curve of the material.

Recently Lundquist, Rossman, and Houbolt (reference 1) have used similar tests of rigidly clamped strips to determine the column curve of sheet metals. A special clamping fixture was used and a correction was applied to the column fixity coefficient to take care of deviations from ideal restraint at the ends caused by the elasticity of the clamps and of the specimen.

Accomplishment of the second purpose appeared desirable as a result of a large amount of experience with compressive tests. It was found that compressive tests in testing machines which had a tendency towards lateral displacement of the upper head relative to the lower head resulted in premature failure of the specimen. Such failures would be prevented if the specimen were placed between the heads of a subpress which would keep the load in line regardless of relative displacement of the heads of the testing machine.

This paper describes the subpress and gives the results of compressive tests with the subpress on a sheet of aluminum alloy 24S-RT 0.032 inch thick by the pack method (reference 2) and by the single-thickness method (reference 3).

THE SUBPRESS

The subpress is shown in the drawings (figs. 1 to 3) and photographs (figs. 4 and 5). The dimensions of the parts are given in table 1.

Special consideration was given to the design of the plunger. In order to obtain nearly axial loading without an excessively long plunger, it was necessary to have very little clearance between the plunger and the guide block. In the subpress, as constructed, the minimum clearance was approximately 0.00035 inch. A decrease in this clearance due to lateral expansion of the plunger under the action of the test load was prevented by applying

this load through a push rod acting on the portion of the plunger between the guide block and the specimen. The load was transmitted through a spherical bearing at the lower end of the push rod. The upper end of the push rod was a spherical surface concentric with the bearing so that the line of application of the load remained as nearly as possible coaxial with the plunger during a lateral displacement of the heads of the testing machine relative to each other. As a result normal forces and hence frictional forces between the plunger and the guide block were kept to a minimum. The sliding surface of the plunger was chromium-plated to prevent corrosion.

The subpress was provided with built-in clamps for fixed-end tests and bearing blocks for flat-end tests. The upper bearing block is a permanent magnet of sufficient strength to hold itself against the plunger. Provision was made for screws for adjusting the pins for pack tests. Space was provided for jigs for applying lateral support, such as the Montgomery fixture used in single-thickness tests.

COMPRESSIVE TESTS IN THE SUBPRESS

Specimens

Compressive tests were made by the pack method and by the single-thickness method on specimens of aluminum alloy 24S-RT sheet 0.032 inch thick. The specimens were taken from the sheet in the direction of rolling (longitudinal) and across the direction of rolling (transverse). Duplicate tests of each kind were made. The specimens were cut from the central portion of the sheet. The location of each specimen was chosen to eliminate as far as possible the effect of variation in properties in different portions of the sheet. The specimens for the packs were from locations between the corresponding pairs of single-thickness specimens.

Pack Tests

Each pack was composed of a 0.52-inch wide middle specimen and twelve 0.50-inch wide supporting specimens. The specimens were clamped together near the ends between pieces of 3/16-inch square cold rolled steel. These

clamps were left on during the test. Each pack was about 2.1 inches long.

The cross-sectional area of each pack was determined by the weight method (reference 4).

The packs were tested, (fig. 6) between hardened and ground steel bearing blocks with the subpress in a beam and poise, screw-type testing machine having a 5-kip and a 50-kip poise. To apply the load uniformly, a shim of plaster of paris was cast between the upper block and a block in contact with the movable head of the subpress. The plaster of paris set while the specimen was under the initial load.

Lateral support against buckling was provided on each side of the pack by 33 pins in 3 columns of 11 rows, spaced on 3/16-inch centers.

Strain was measured by a pair of Tuckerman 1-inch optical strain gages. The gages were attached to opposite edge faces of the middle specimen.

The results of the tests are given in table 2 and the stress-strain curves are shown in figures 7 and 8. The value of Young's modulus for each specimen is the slope of a least-square straight line fitted to the lower portion of the stress-strain curve. The yield strength (offset = 0.2 percent) was obtained from the stress-strain curve and the experimental value of Young's modulus.

Single-Thickness Tests

The single-thickness tests were made on specimens nominally 5/8 inch wide by 2 $\frac{5}{8}$ inches long. Lateral support against premature buckling was provided by a fixture (reference 3) having roller guides spaced on 0.1-inch centers.

The cross-sectional area of each specimen was determined by the weight method (reference 4).

The specimens were tested, figure 9, between hardened and ground steel bearing blocks with the subpress in a beam and poise, screw-type testing machine of 50-kip capacity with the 5-kip poise.

Strain was measured by a pair of Tuckerman 1-inch optical strain gages. The gages were attached to opposite edge faces of the specimen.

The results are given in table 2 and the stress-strain curves are shown in figures 10 and 11.

Discussion

The values of Young's modulus in both the longitudinal and transverse directions ranged from 10,650 to 10,750 kips per square inch, and the average value was 10,694 kips per square inch. The maximum variation from the average was less than 0.6 percent.

The values of yield strength (offset = 0.2 percent) in the longitudinal direction ranged from 57.0 to 57.4 kips per square inch, and their average value was 57.22 kips per square inch. The maximum variation from the average was less than 0.4 percent. The yield strengths in the transverse direction ranged from 61.3 to 61.4 kips per square inch, and their average value was 61.38 kips per square inch. The maximum variation from the average was less than 0.2 percent.

The stress-deviation curves, (figs. 12 and 13) were plotted to facilitate comparison of the curves from pack and single-thickness tests for a given direction. For these curves the values for deviation were computed by subtracting from a given value of strain a value obtained by dividing the corresponding stress by an average value of Young's modulus. For the longitudinal specimens the average value was 10,712 kips per square inch, and for the transverse specimens 10,675 kips per square inch.

The stress-deviation curves show close agreement between stress-strain data from tests of flat-end packs and those from tests of single-thickness specimens.

CONCLUSIONS

The compressive tests made with the subpress gave very consistent results. Practically identical stress-strain curves were obtained by the pack method and by

the single-thickness method for 0.032-inch aluminum alloy 24S-RT sheet.

National Bureau of Standards,
Washington, D. C., September 29, 1943.

REFERENCES

1. Lundquist, Eugene E., Rossman, Carl A., and Houbolt, John C.: A Method for Determining the Column Curve from Tests of Columns with Equal Restraints against Rotation on the Ends. T.N. No. 903, NACA, 1943.
2. Aitchison, C. S., and Tuckerman, L. B.: The "Pack" Method for Compressive Tests of Thin Specimens of Materials Used in Thin-Wall Structures. Rep. No. 649, NACA, 1939.
3. Paul, D. A., Howell, F. M., and Grieshaber, H. E.: Comparison of Stress-Strain Curves Obtained by Single-Thickness and Pack Methods. T.N. No. 819, NACA, 1941.
4. Miller, James A.: Determination of Cross-Sectional Areas of Structural Members. Res. Paper 1258, Natl. Bur. of Standards Jour. Res., vol. 23, Nov. 1939, pp. 621-636.

TABLE 2.- RESULTS OF COMPRESSIVE TESTS ON 0.032-INCH ALUMINUM ALLOY 24S-RT SHEET

Specimen	Test	Direction	Number of specimens	Cross-sectional area (sq in.)	Young's modulus (kips/sq in.)	Yield strength (Offset = 0.2 percent) (kips/sq in.)
C1L	Flat-end pack	Longitudinal	13	0.2217	10,720	57.0
C2L	---do---	---do---	13	.2218	10,720	57.2
M1L	Single-thickness	Longitudinal	1	.0212	10,710	57.4
M3L	---do---	---do---	1	.0213	10,700	57.3
C1T	Flat-end pack	Transverse	13	.2221	10,650	61.3
C2T	---do---	---do---	13	.2219	10,650	61.4
M1T	Single-thickness	Transverse	1	.0213	10,750	61.4
M4T	---do---	---do---	1	.0212	10,650	61.4

TABLE I.--DIMENSIONS OF THE PARTS OF THE SUBPRESS

Name	Symbol and figure number	Length (in.)	Width (in.)	Thickness (in.)	Diam- eter (in.)	Size- thread	Remarks*
6-inch ship channels	A-1,2,3	17 $\frac{13}{16}$					Weight 15.3 pounds per linear foot.
Upper backing plate	B-1,2	7 $\frac{1}{8}$	5	3/4			
Lower backing plate	C-1,3	3	5	3/4			
Guide block	D-1	7 $\frac{9}{16}$	5 $\frac{9}{16}$	6			Diameter of hole 2 $\frac{1}{2}$ inches.
Spacer block	E-1,2,3	3	5 $\frac{9}{16}$	6			Tight fit on stationary head.
Stationary head	F-1,2,3	4 $\frac{1}{2}$			2 $\frac{1}{2}$		Diameter reduced to 2.45 inches for upper 1 $\frac{1}{2}$ inches. Extends below spacer block so that spacer block clears head of machine.
Plunger	G-1,2	13 $\frac{3}{8}$			2 $\frac{1}{2}$		Diameter reduced to 2.45 inches for lower 1 $\frac{1}{2}$ inches.
Push rod	H-1,2	11 $\frac{1}{4}$			1 $\frac{1}{8}$		Top surface spherical, concentric with steel ball J at lower end.
Centering ring	I-1,2	1/8			2 $\frac{1}{2}$		Hole in center for easy sliding fit on push rod H; relieved for lower 3/32 inch.
Steel ball	J-1				3/4		
Hemispherical bearings	K-1,2,3				5/8		
Clamp reaction blocks	L-1,2,3	4	4	1 $\frac{1}{2}$			Hole in center for close sliding fit on reduced ends of parts F and G.
Seating plates	M-1,3			1/32	5/8		
Jaw plates with vertical axis	N-1,2,3	9/16	1/2		1/2		Half cylinder. Has slot (not shown) for retaining pin (not shown) in clamp O.
Clamp for jaw plates N	O-1,2,3	1			3/4		Close sliding fit in clamp holes in plunger and stationary head.
Jaw plates with horizontal axis	P-1,2,3	23/32	9/16		9/16		Half cylinder with ends relieved for loose fit in clamp hole in plunger or stationary head.

*All parts steel except where noted.

TABLE I.-- (concluded)

Name	Symbol and figure number	Length (in.)	Width (in.)	Thick- ness (in.)	Diam- eter (in.)	Size- thread	Remarks*
Clamps for jaw plates P	R-1,2,3	1			3/4		Close sliding fit in clamp holes in plunger and stationary head.
Pins to restrict rotation of clamps	T-1				3/32		
Holes for screws for pack test	U-1,2,3					6-40	Spaced on 3/16-inch centers.
Guides to restrict rotation of plunger	V-1						Two 3/8-inch bolts with 1/4-inch brass inserts in head. Average clearance with channel 0.005 inch.
Backing plate bolts						1/2-20	Not marked on drawings.
Set screws for clamp reaction blocks						3/8-16	Do.
Clamp bolts							Do.
Dust washers							Not shown on drawings, material felt.
Dust washer retainers	4,5,6						Do. , material brass.
Counterweights for plungers	5						Do.
Handles	4,5						Do.
Oil cup	4,5						Do. , material brass.
Bearing blocks	9						Do. , separate hardened and ground steel blocks.

*All parts steel except where noted.

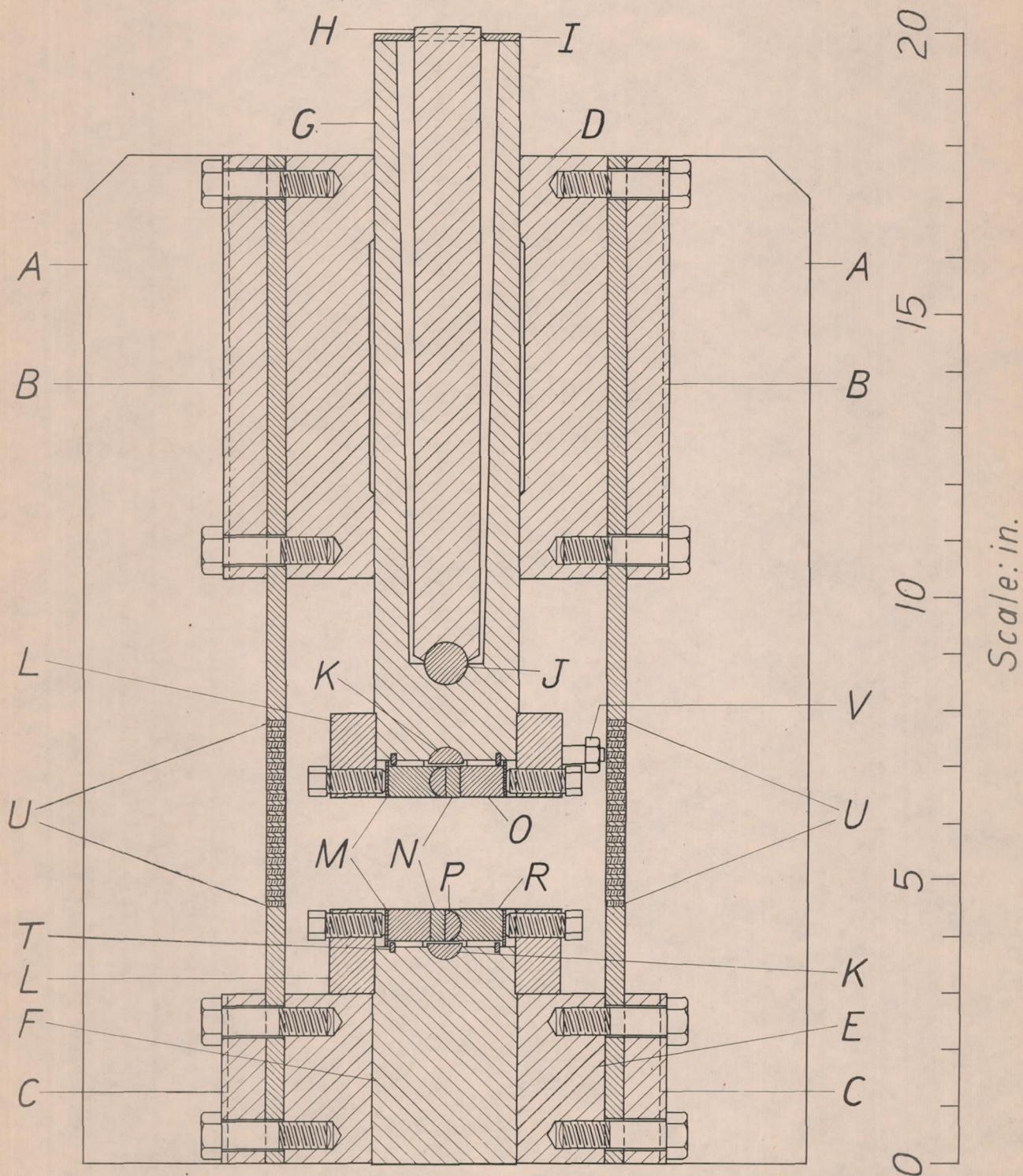


Fig. 1. Subpress, front elevation, section at center.

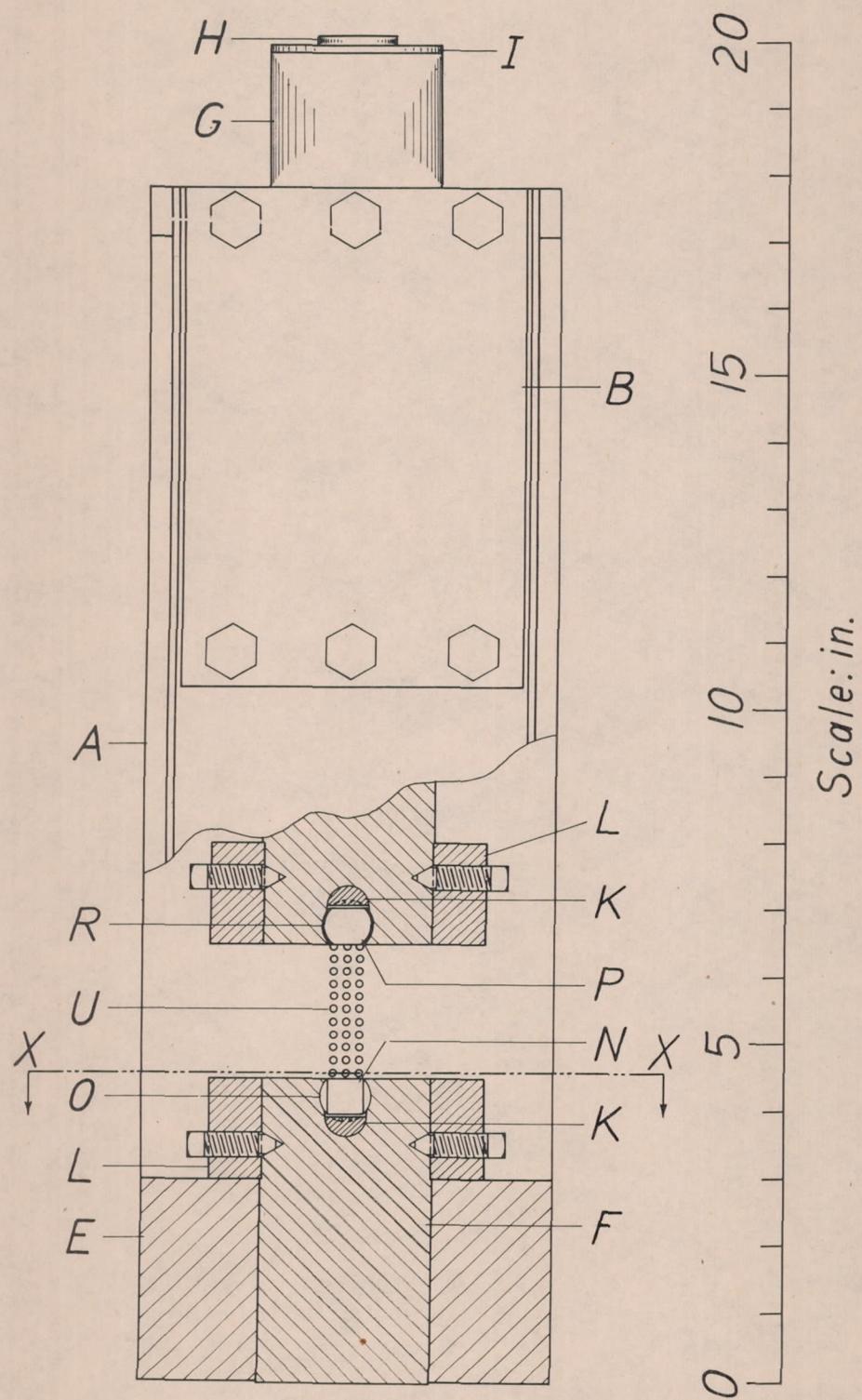
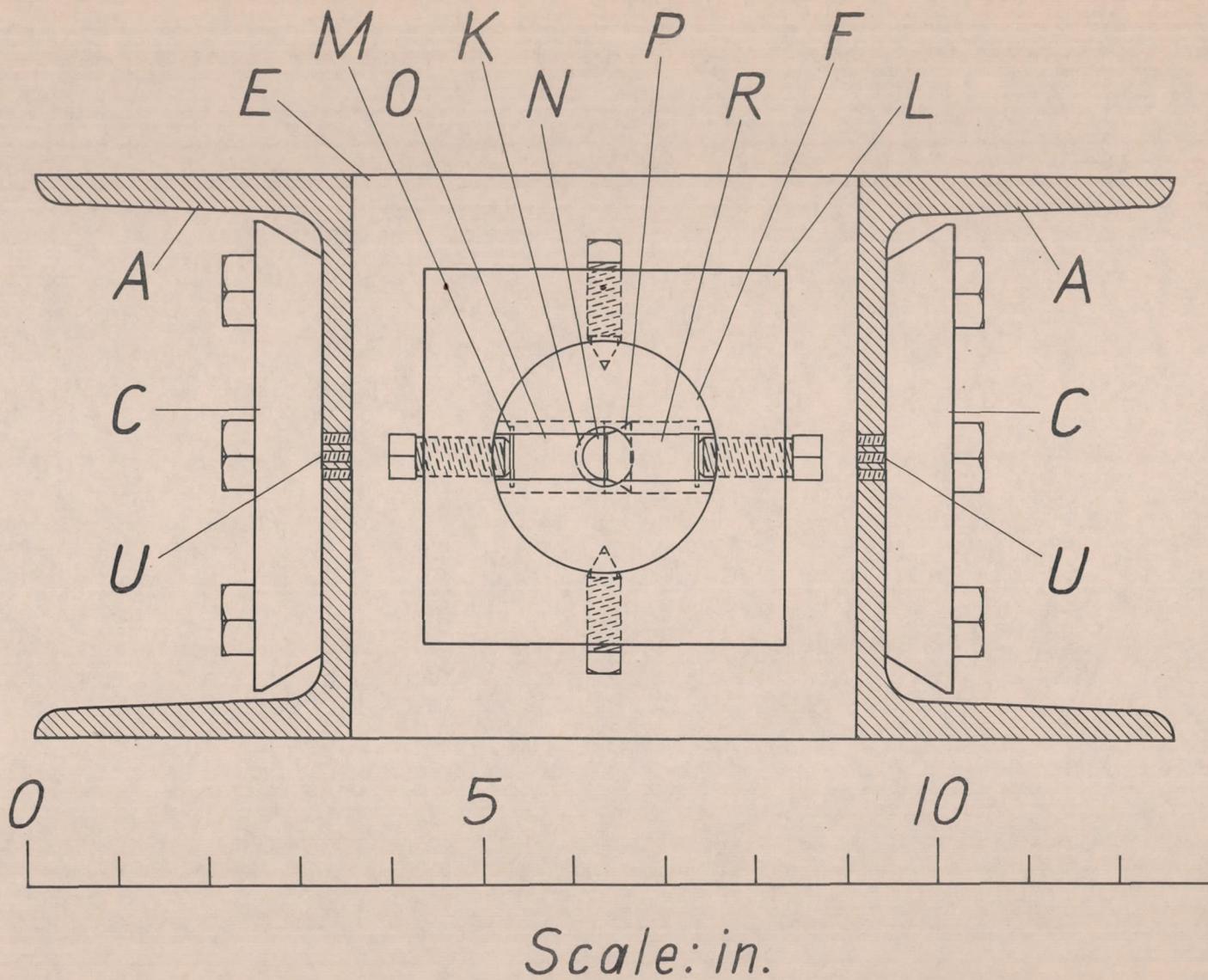


Fig. 2. Subpress, side elevation, part section at center.



Scale: in.

Fig. 3. Subpress, plan, section at X-X, figure 2.

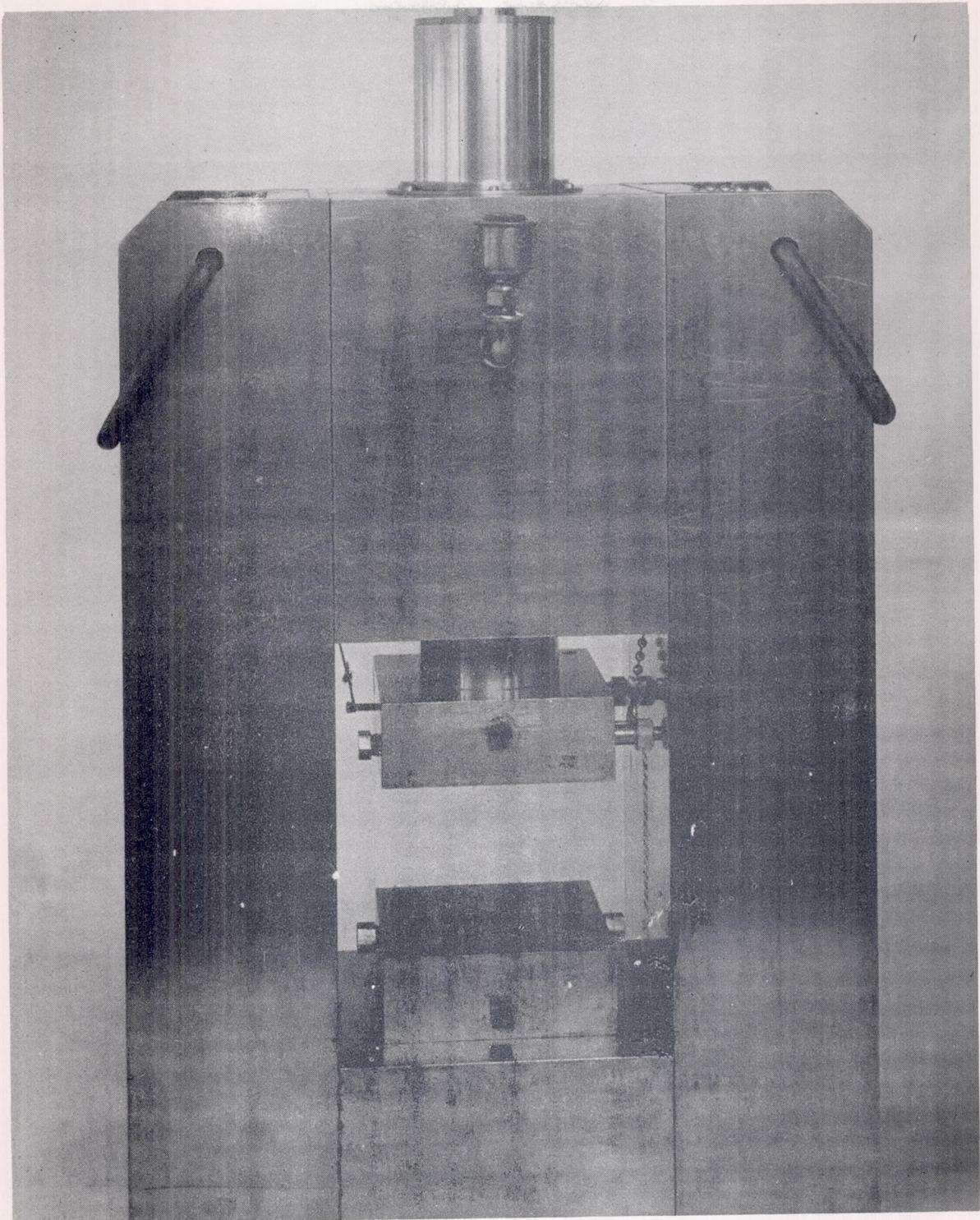


Fig. 4. Subpress, front view.

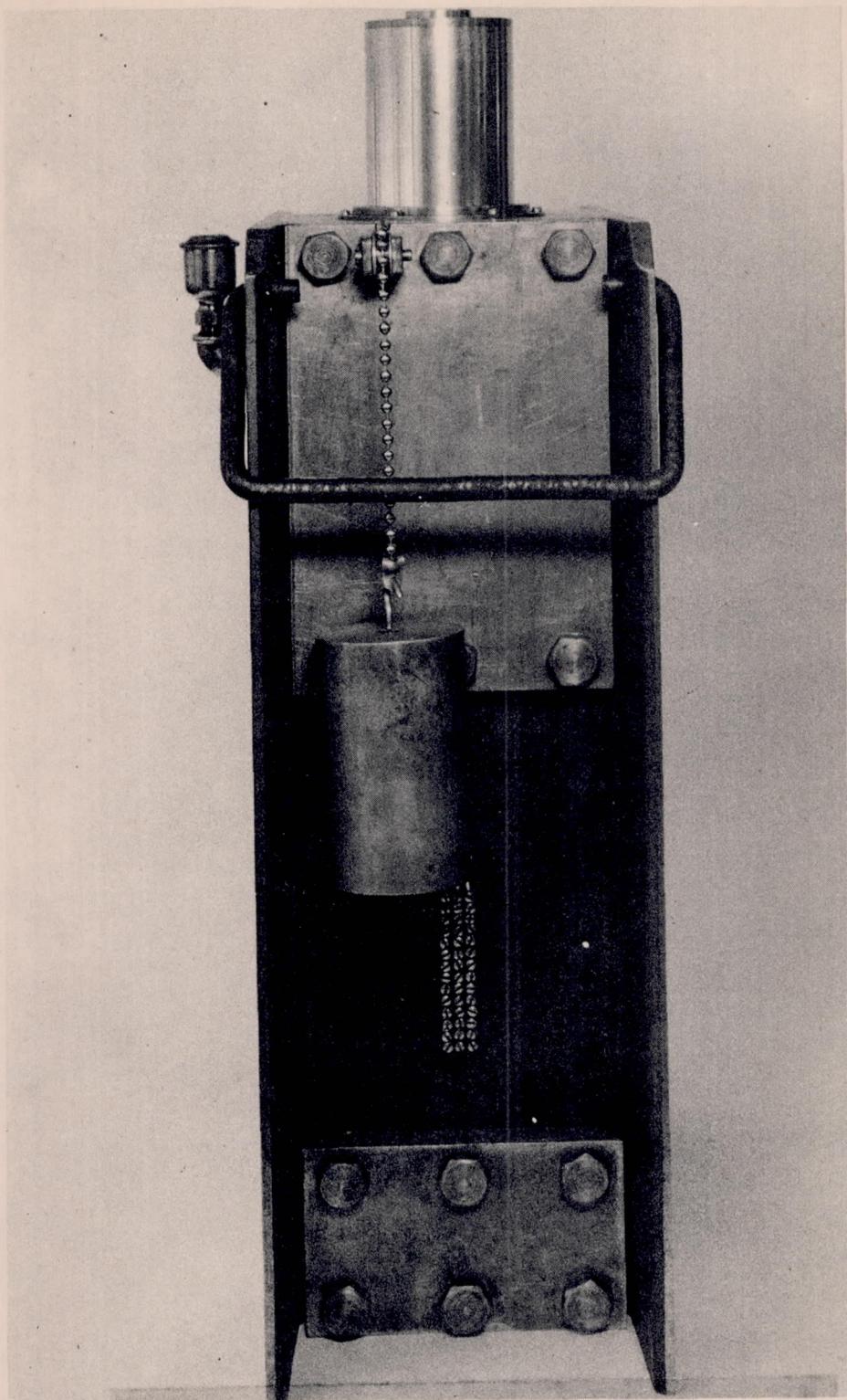


Fig. 5. Subpress, side view.

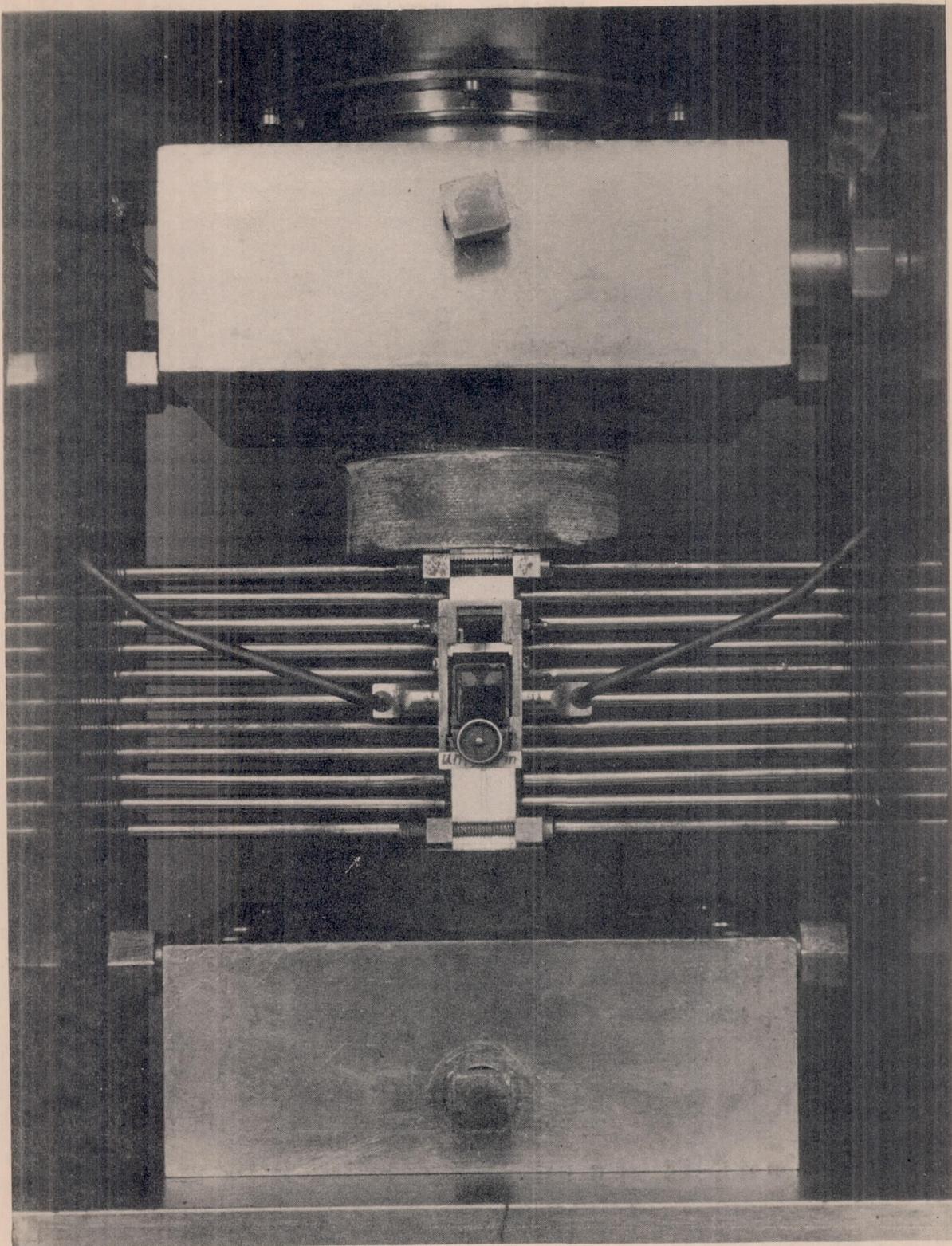


Fig. 6. Pack compressive test with suppress.

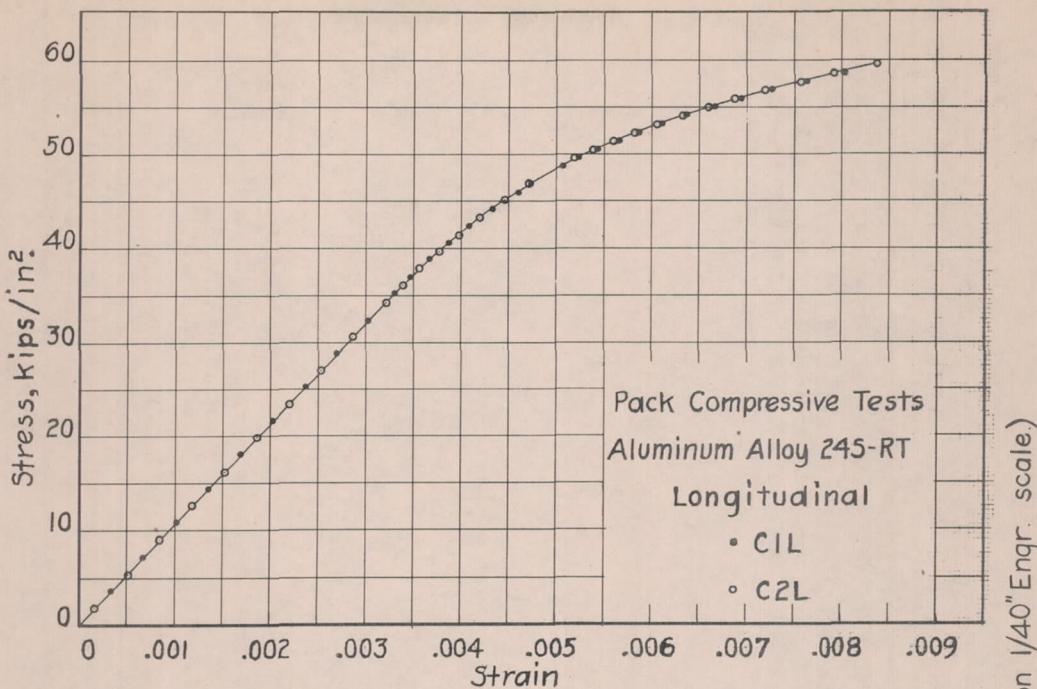
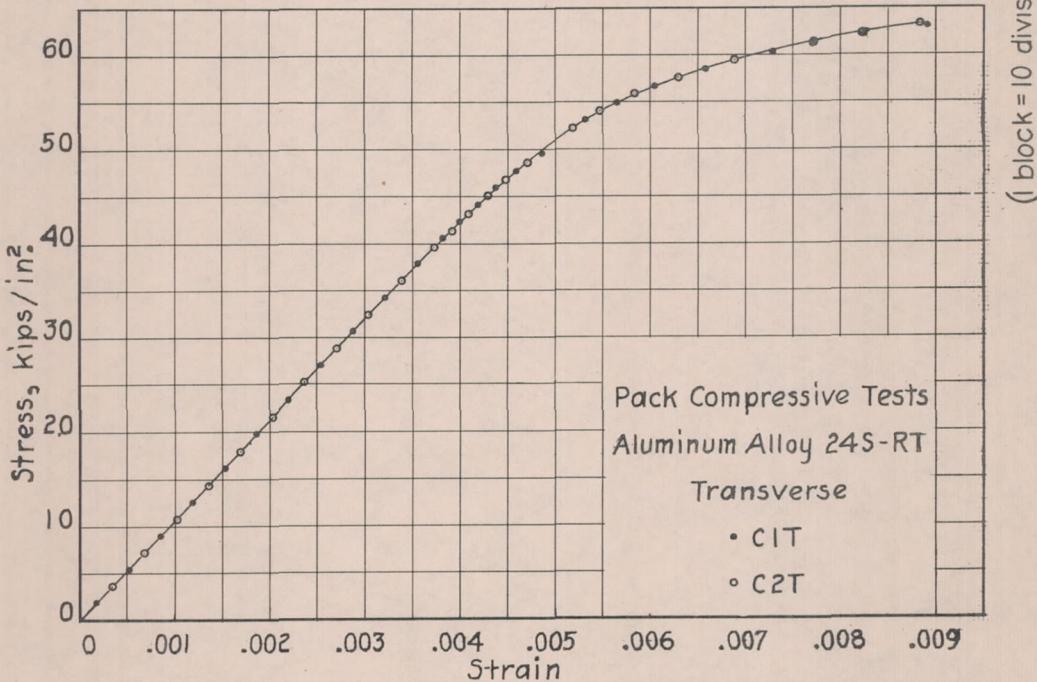


Figure 7.- Compressive stress-strain curves, 0.032-in. aluminum alloy 24S-RT sheet, longitudinal packs.



(1 block = 10 divisions on 1/40" Engr. scale)

Figure 8.- Compressive stress-strain curves, 0.032-in. aluminum alloy 24S-RT sheet, transverse packs.

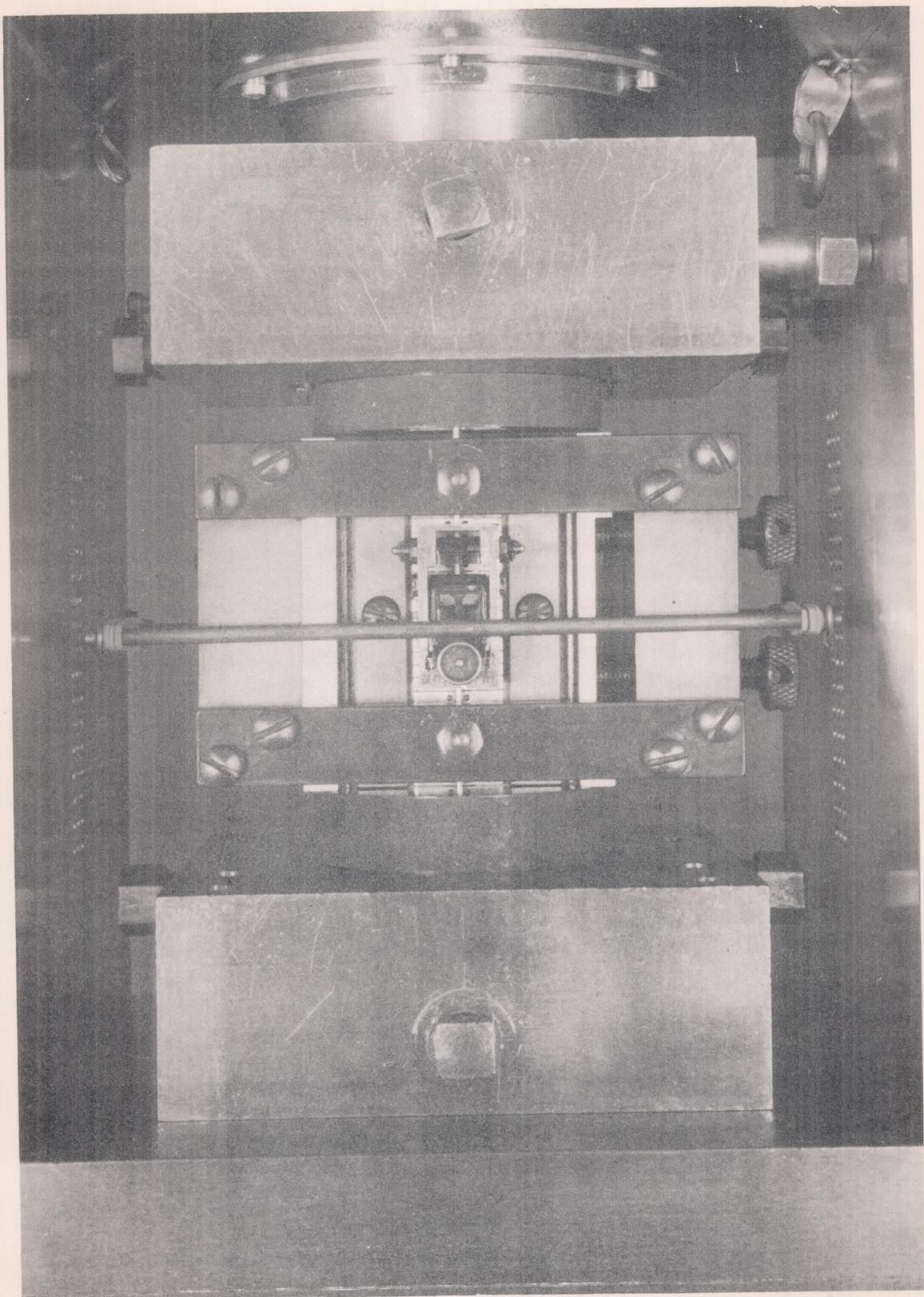


Fig. 9. Single-thickness compressive test with subpress.

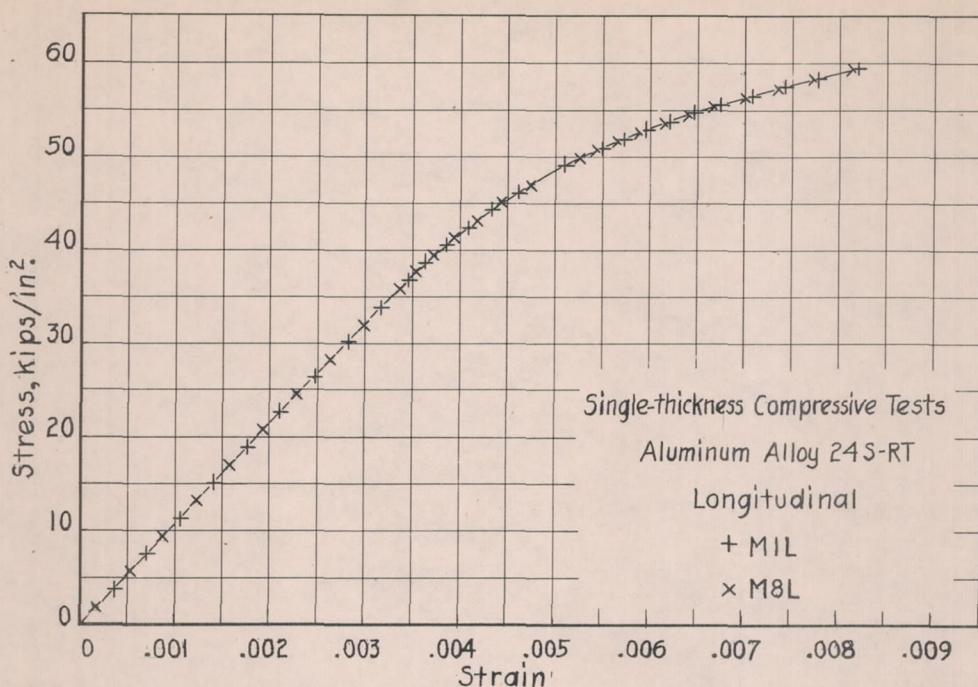


Figure 10.- Compressive stress-strain curves, 0.032-in. aluminum alloy 24S-RT sheet, longitudinal single-thickness specimens.

(block = 10/40")

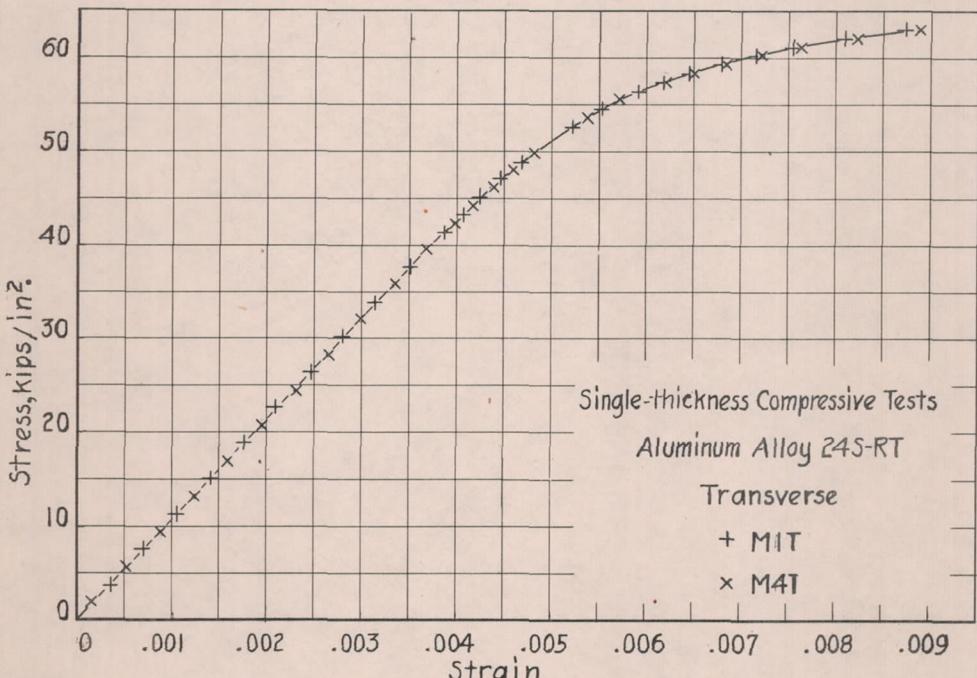


Figure 11.- Compressive stress-strain curves, 0.032-in. aluminum alloy 24S-RT sheet, transverse single-thickness specimens.

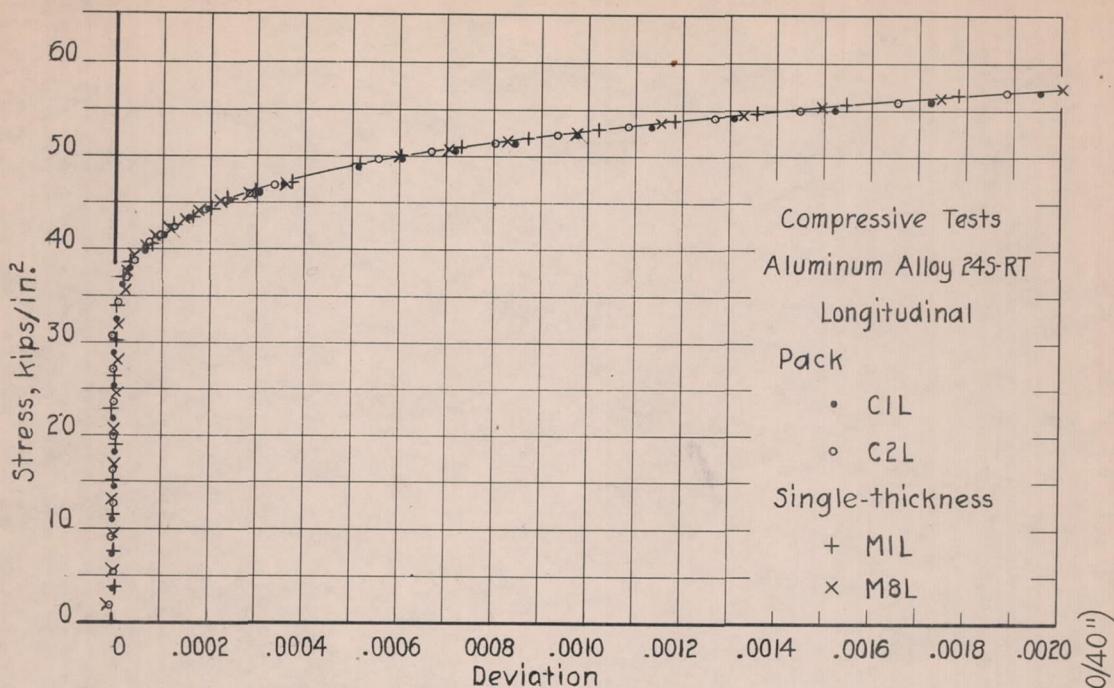


Figure 12.- Compressive stress-deviation curves, 0.032-in. aluminum alloy 24S-RT sheet, longitudinal specimens.

(1 block = 10/40")

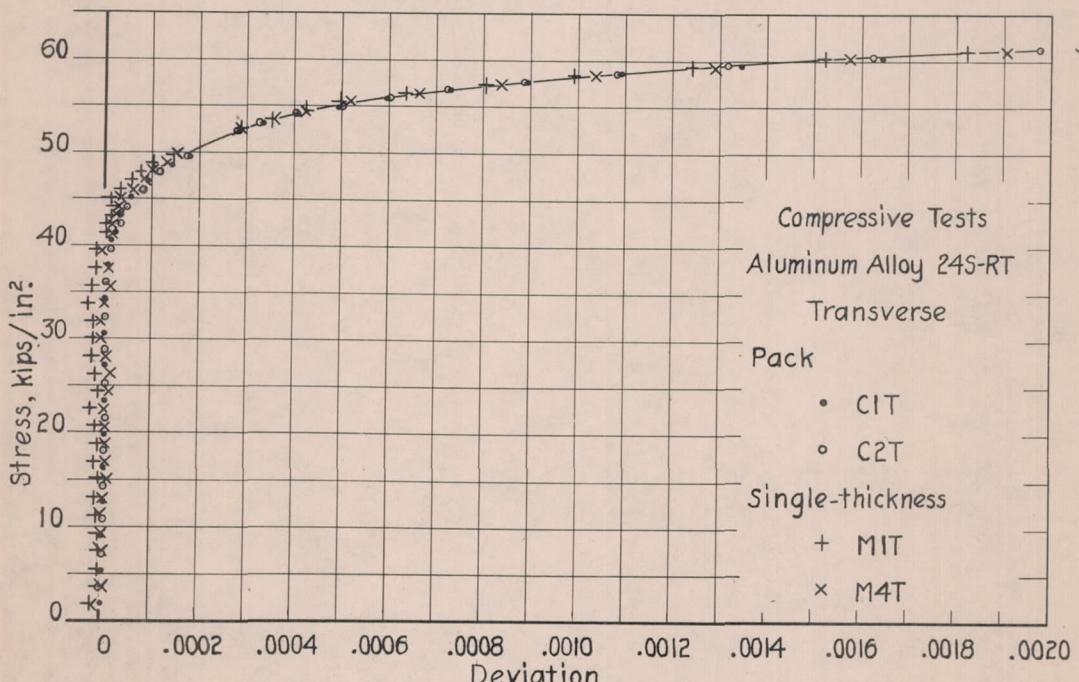


Figure 13.- Compressive stress-deviation curves, 0.032-in. aluminum alloy 24S-RT sheet, transverse specimens.